Report on SF system studies

- Monte Carlo and Data show no compatibility at the SF.

- This should be improved for the ANN analysis to be successful.

- Methods under study :
  - Improve pulse height (and hit) generation on MC data (SF2 decoder) and add background in MC (hybrid MC files)
  - Subtract background from data (pulse height cut)

- For both we need to understand the background and its origin.

Possible origin of background hits

(A) Muon interactions in the target stand or at the sides of the analysis magnet or at the sides of the emulsion target

- Flux of interactions in depth x : $\frac{\mathbf{dN}}{\mathbf{N}} = \frac{\mathbf{N_A \cdot \rho \cdot \sigma}}{\mathbf{A}} \cdot \mathbf{dx}$

where N_o the initial flux of muons in the target area

ρ the density of the material

σ the interaction cross section

with $N_o \sim 20000\ \mu/10^{13}$ POT /spill, $\rho \sim 8$ gr/cm^3, A ~ 60

$\sigma \sim 2.9\text{x}10^{-8}\, E_\mu^{\ 0.73}$ barns , x ~ 3m and surface ~ 3.2 10^4 cm^2

We get :

number of muon interactions (magnet steel) ~ 4x10^{-1}/spill and even less in the target or in the target stand.

Possible origin of background hits 2

(B) Interactions of neutrons in the target area.

- With the previous values except $\sigma \sim 50$ mbarns and the mass and surface of the target area we get :

Percentage of neutron interactions $N/N_o \sim 5x10^{-2}$

so to obtain one neutron interaction per 1 ms we have to have a flux of 20000 neutrons per spill.

(C) Photon interactions that enter the emulsion target area.

- In this case the background hits should be more correlated spatially due electromagnetic shower development (?)

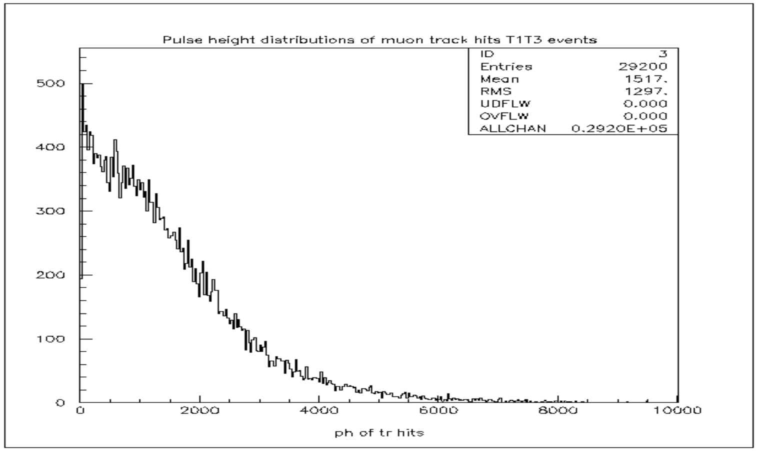
Pulse height study for T1T3 events 1

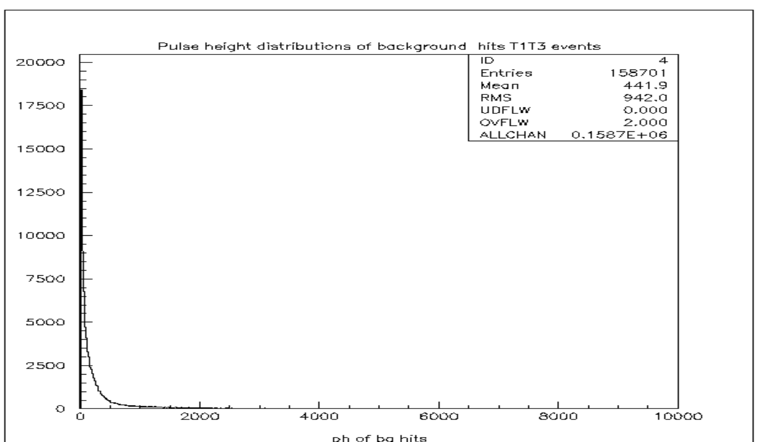
- Used T1T3 events that contained muons (one final track passing throughout the spectrometer)

- Considered all the SF hits that do not belong to the muon track as background hits

- Used 1500 such events and made the following distributions

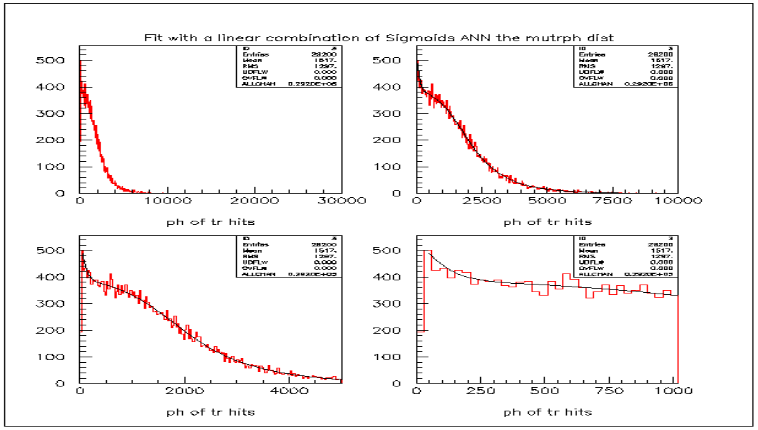
Pulse height study for T1T3 events 2

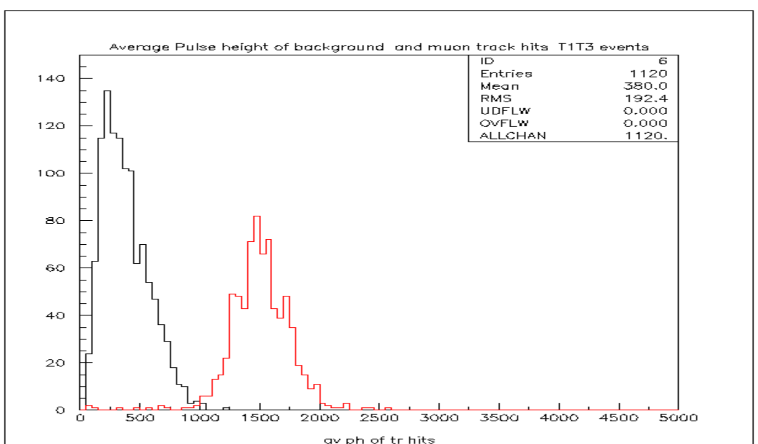




- The top histogram is the pulse height distribution of all the hits that belonged to the muon tracks
- The bottom is the pulse height distribution of all the background hits
- It is obvious that the background hits have much smaller pulse heights compared to these of the muon hits.
- The top distribution was expected to be a Landau distorted to smaller pulse heights due to the fiber geometry.
- It is clear that there is also a presence of an additional component than just muon hits

Pulse height study for T1T3 events 3





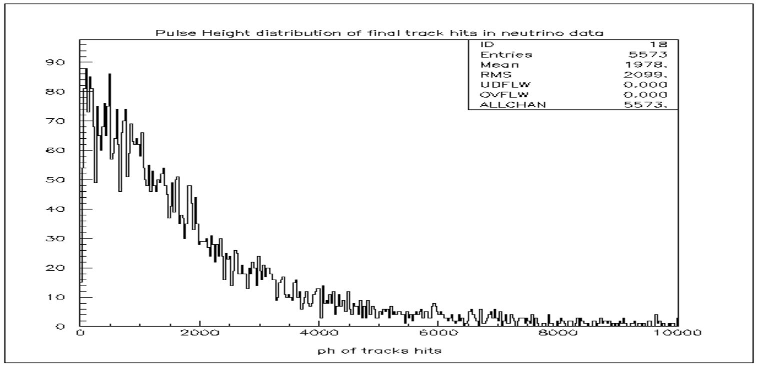
- In the top figure we see the previous pulse height distribution(muon hits) fitted with the use of ANN. We also get an as good fit as this one with a Landau plus an exponential distribution. The results is quite good and could be used in MC to generate SF hits and pulse heights (under study)

- In the bottom figure we can see the average (per hit) pulse height distributions for muon and background hits. They show no overlapping in accordance with the previous distributions.

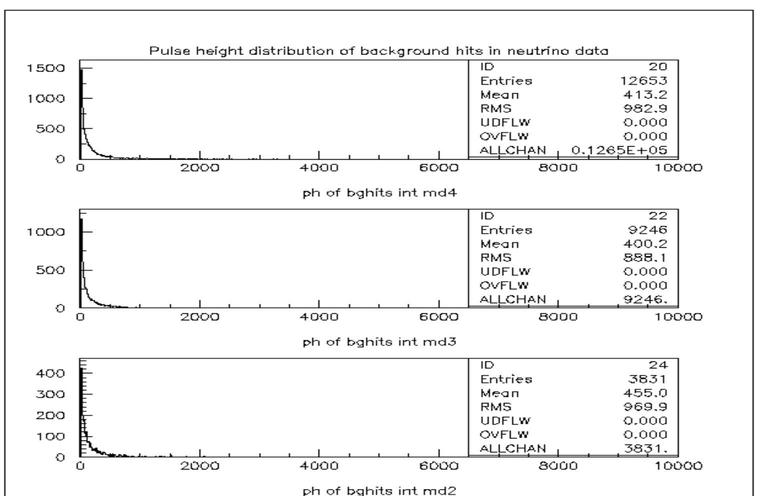
Pulse height study for neutrino events

- Used 203 neutrino events.
- Considered all the hits in the SF stations upstream of the interaction module as background hits and all the hits after (downstream) the interaction module as interaction hits.
- Made the same pulse height distributions with these of T1T3 events for comparison

Pulse height study for neutrino events 1

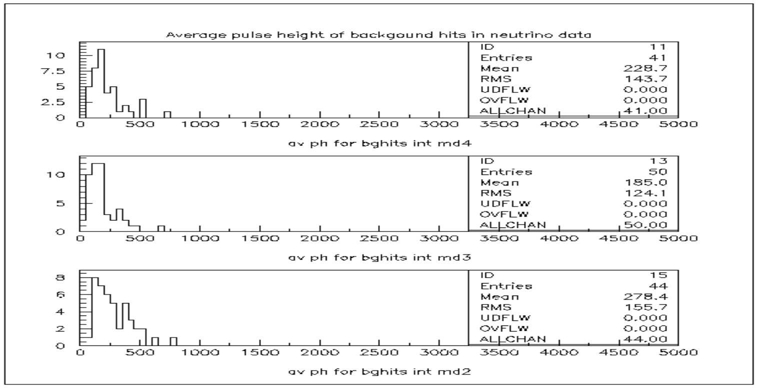


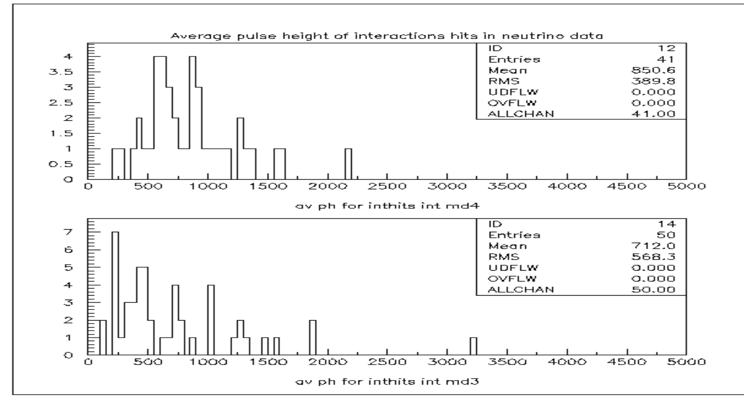
- In the top histogram we see the pulse height distribution of tracks hits in neutrino interactions. The distribution looks similar to one of T1T3 events (mean ~ 1500 in T1T3 , mean ~ 1900 at neutrino).



- On the bottom figure there are the pulse height distributions for background hits in neutrino interactions and again are similar to the one in T1T3 events.(mean ~ 400 in both T1T3 and neutrino events)

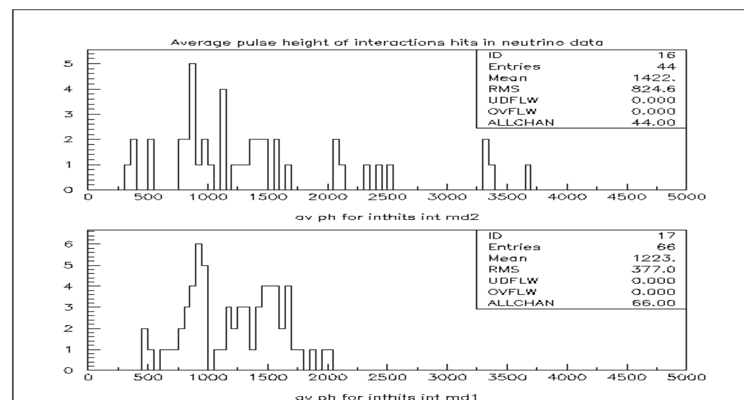
Pulse height study for neutrino events 2





• On the top left figure we see the average pulse height for background hits. It is not significantly different of the T1T3 events (mean ~ 250 for both)

• On the other 2 figures we see the average pulse height for interactions hits. They have slightly different mean values to that of T1T3 events (mean ~ 1000 in neutrino mean ~ 1500 in T1T3) but we should consider that the "interaction" hits in neutrino data could contain background hits as well.



Conclusions (SF pulse height study)

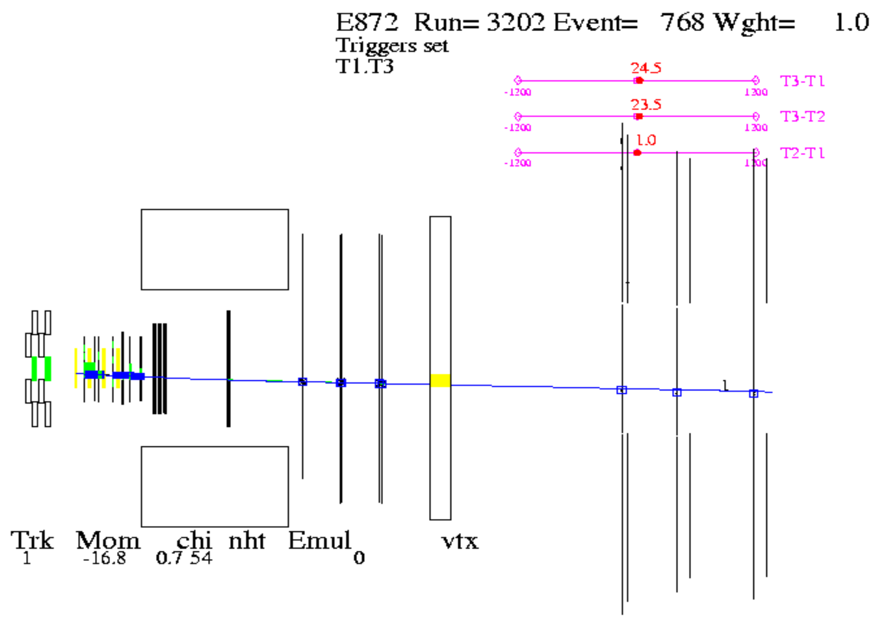
- The pulse heights of background hits and interaction hits are different.
- T1T3 events and neutrino events show similarity on pulse height behavior of background hits and interaction hits.
- In both there seems to be a 400 (?) cut under which we could safely say that this hit is a background one (needs to be studied further in order to eliminate background hits from data).
- The track pulse height distribution of T1T3 events could be used to obtain a better parameterization of pulse height in MC (under study).

Hybrid MC method

- **Main idea :** Find - select from data events that are not neutrino interactions but only background.

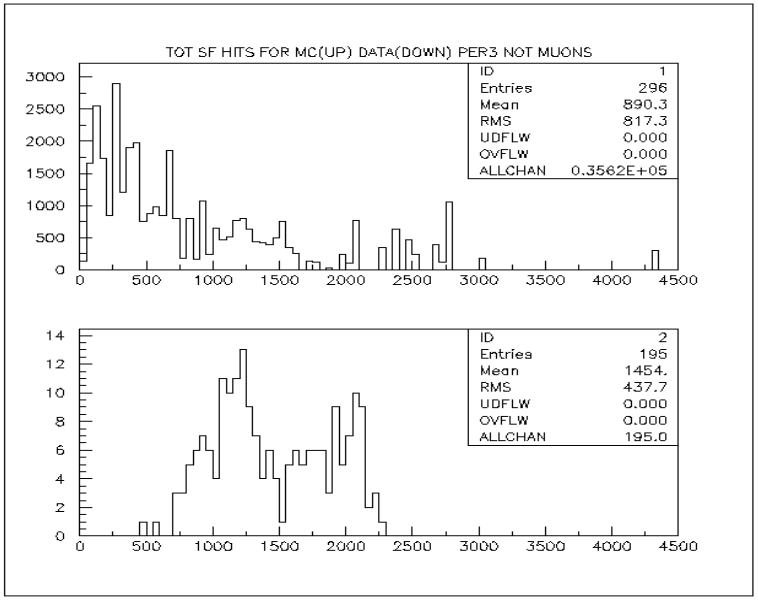
- Method(s) :
  - Remove from T1T3 events that have straight muons the "muon" hits and keep the rest as the desired "empty frame".
  - Scan raw data and select "empty frames" based on some criteria.
  - Select from the 203 neutrino interactions the ones that occurred at the last emulsion module and use the information in the previous ones as "background" (test case) .

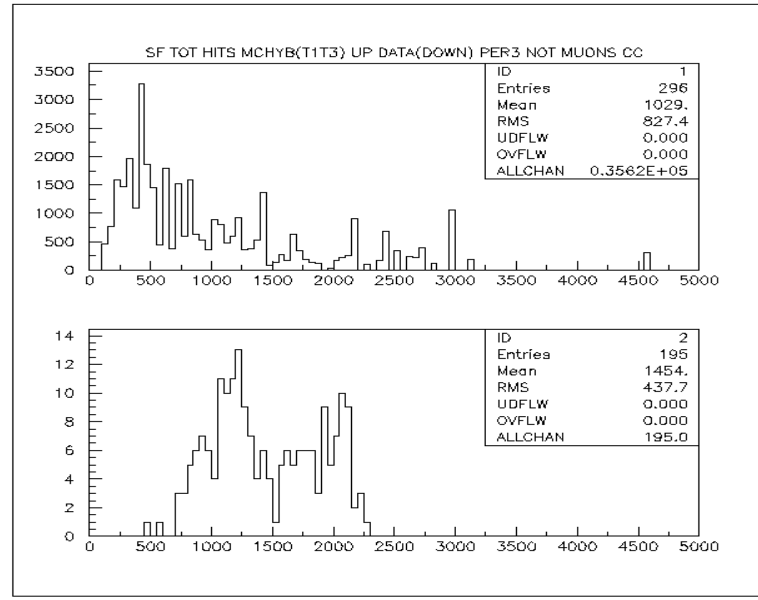
T1T3 Events



- T1T3 events that have straight muons look like the top figure.
- We remove all the hits associated with the muon and overlay the rest information on MC events.

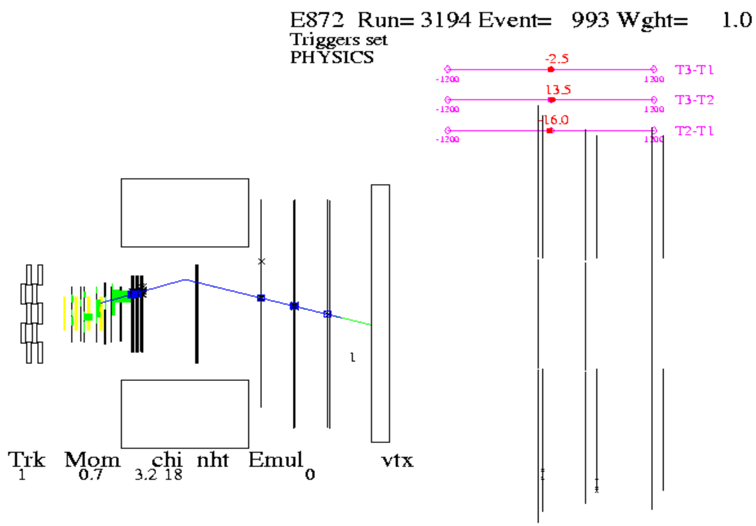
T1T3 Events -Results





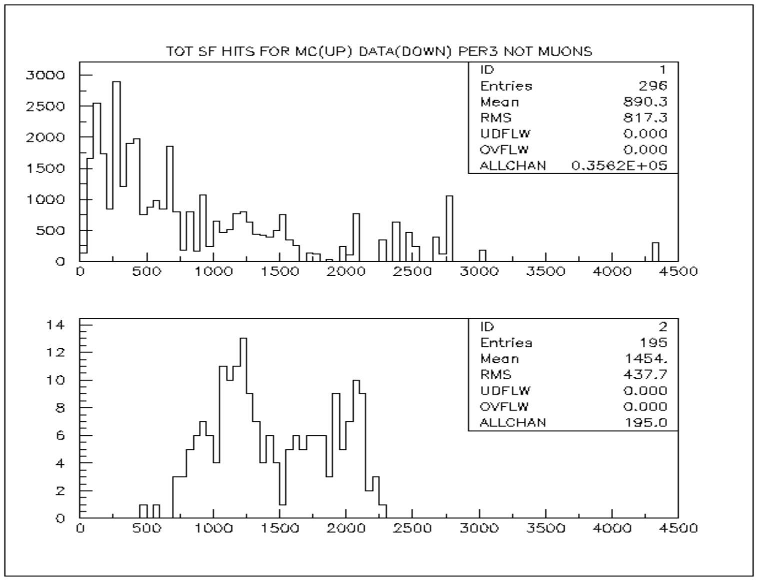
- On the left we see the total sf hits distribution for mc(up) and data(down). On the right we see the same but for mc hybrid data.
- There is a slight improvement but certainly not the desired one since the t1t3 events did not obviously have the same number of background hits as real data.

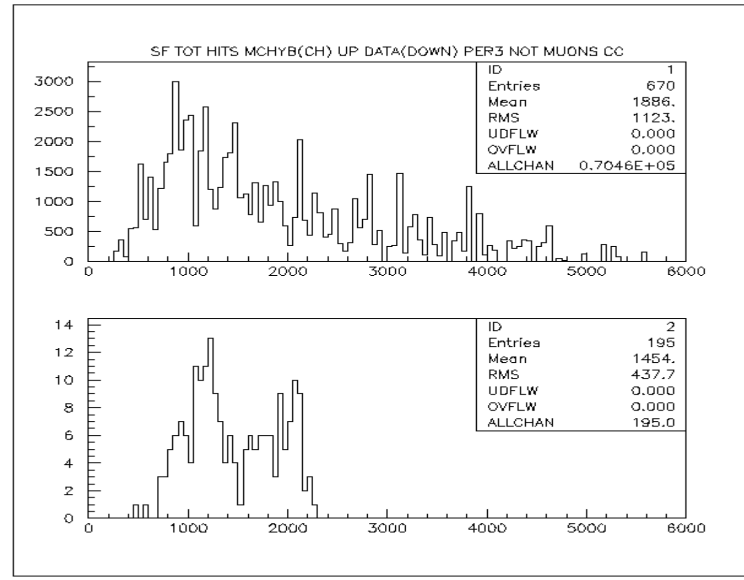
Background selection from raw data



- In the side figure we see one of the events that was selected as "background" by setting the following criteria :
  - Number of sf tracks = 0
  - Number of dc tracks <= 1
  - Number of final tracks <=1
  - Number of dc hits <=35
  - Total EMCAL energy <= 3 GeV
  - Total pulse height <=1000x10^3

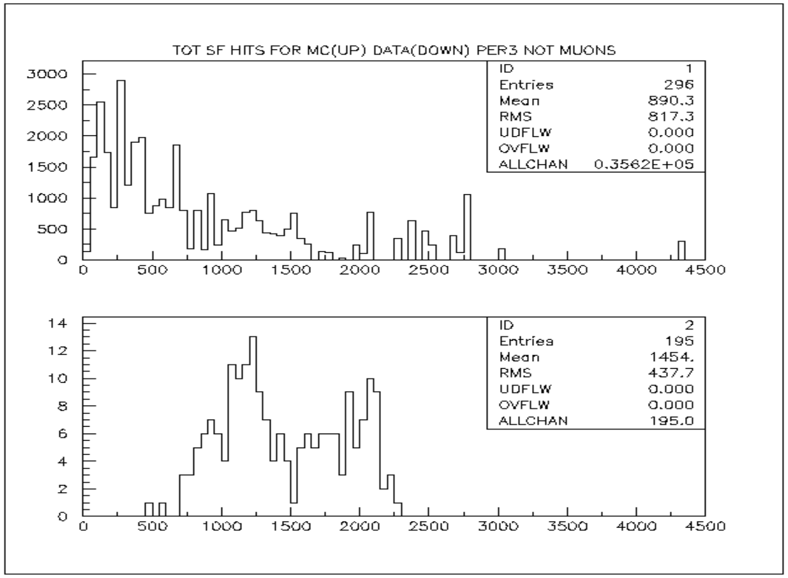
Results for background selection from data

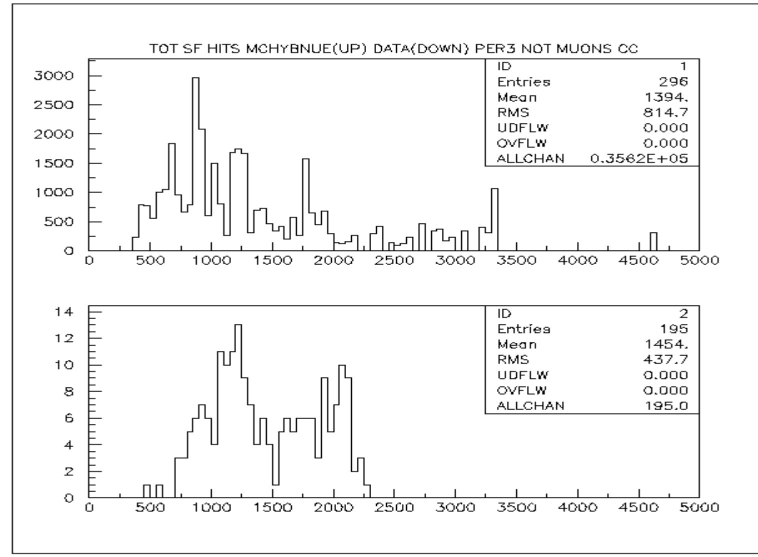




- On the left we see the total sf hits distribution for mc(up) and data(down). On the right we see the same but for mc hybrid data .
- They are still not compatible but this very first attempt on background selection from raw data seems better than use t1t3 events.

Background selection from neutrino data





- On the left we see the total sf hits distribution for mc(up) and data(down). On the right we see the same but for mc hybrid data .
- Still we do not reproduce the same “picture” but by “eye” scan is probably the best attempt of all if we take under consideration that in SF station four there was no background added!!

Conclusions (Hybrid MC)

- None of the three methods so far gave satisfactory results.

- Possibly the main problem in this approach is to understand the origin and the characteristics of background in neutrino interactions and thus be more efficient in selecting it.